TEXTBOOK EXERCISES

Textbook Exerciseലെ ചോദ്യങ്ങളുടെ ഉത്തരങ്ങൾ മാത്രമേ നൽകിയിട്ടുള്ളൂ. ചോദ്യ നമ്പരുകൾ NCERT Textbookലെ ക്രമത്തിലാണ്.

2.1.(i) Mass of an electron $= 9.11 \times 10^{-31}$ kg

No. of electrons in 1 g ie, 10^{-3} kg

$$= \frac{\text{Mass}}{\text{Mass of one electron}} = \frac{10^{-3}\text{kg}}{9.11\times10^{-31}\text{kg}}$$

$= 1.098 \times 10^{27}$ electrons

(ii) Mass of one mole electrons

= No. of electrons × Mass of one electron

$= 6.022 \times 10^{23} \times 9.11 \times 10^{-31} = 5.486 \times 10^{-7}$ kg

Charge of one mole electrons

= No. of electrons × charge of one electron

$= 6.022 \times 10^{23} \times 1.602 \times 10^{-19}$ C $= 9.65 \times 10^4$ C

2.2. (i) Number of electron in 1 molecule of methane (CH_4)

$= 6 + 4 = 10$ electrons

∴ 1 mole of methane $= 10 \times 6.022 \times 10^{23}$

$= 6.022 \times 10^{24}$ electrons

(ii) (a) 1 g atom of ^{14}C = 14g $= 6.022 \times 10^{23}$ atoms

$= 6.022 \times 10^{23} \times 8$ neutrons

14g = 14000 mg ^{14}C $= 8 \times 6.022 \times 10^{23}$ neutrons

$$\therefore 7\text{ mg } ^{14}C = \frac{8\times6.022\times10^{23}\times7}{14000} = 2.4088 \times 10^{21}$$

(b) Mass of one neutron $= 1.675 \times 10^{-27}$ kg

∴ Mass of 2.4088×10^{21} neutrons

$= 1.675 \times 10^{-27} \times 2.4088 \times 10^{21}$

$= 4.0347 \times 10^{-6}$ kg

(iii) (a) 1 mole of NH_3 ≡

17g NH_3 ≡ 6.022×10^{23} molecules of NH_3

$= 6.022 \times 10^{23} \times (7 + 3)$ protons

$= 6.022 \times 10^{24}$ protons

$$\therefore 34\text{ mg } NH_3 = \frac{6.022\times10^{24}\times0.034}{17}$$

$= 1.2044 \times 10^{22}$ protons

(b) Mass of one proton $= 1.6726 \times 10^{-27}$ kg

Mass of 1.2044×10^{22} protons

$= 1.6726 \times 10^{-27} \times 1.2044 \times 10^{22}$

$= 2.0145 \times 10^{-5}$ kg. There is no effect of temperature and pressure.

2.3.

$^{13}_{6}C$	p = 6	n = 13 – 6 = 7
$^{16}_{8}O$	p = 8	n = 16 – 8 = 8
$^{24}_{12}Mg$	p = 12	n = 24 – 12 = 12
$^{56}_{26}Fe$	p = 26	n = 56 – 26 = 30
$^{88}_{38}Sr$	p = 38	n = 88 – 38 = 50

2.4. (i) $^{35}_{17}Cl$ (ii) $^{233}_{92}U$ (iii) $^{9}_{4}Be$

2.5. $\lambda = 580$ nm $= 580 \times 10^{-9}$ m

$$\text{Frequency, } \upsilon = \frac{c}{\lambda} = \frac{3\times10^{8}\text{ms}^{-1}}{580\times10^{-9}\text{m}} = 5.17 \times 10^{14}\text{ s}^{-1}$$

$$\text{Wave number, } \bar{\upsilon} = \frac{1}{\lambda} = \frac{1}{580\times10^{-9}\text{m}} = 1.72 \times 10^{6}\text{ m}^{-1}$$

2.6. (i) $\upsilon = 3 \times 10^{15}$ Hz

$E = h\upsilon = (6.626 \times 10^{-34}\text{ Js}) \times (3 \times 10^{15}\text{s}^{-1})$

$= 1.988 \times 10^{-18}$ J

(ii) $\lambda = 0.50$ Å $= 0.50 \times 10^{-10}$ m

$$E = \frac{hc}{\lambda} = \frac{(6.626\times10^{-34}\,Js)\times(3\times10^{8}\,ms^{-1})}{0.50\times10^{-10}\,m}$$

$= 3.98 \times 10^{-15}$ J

2.7. Frequency, $\upsilon = \frac{1}{\text{period}} = \frac{1}{2.0\times10^{-10}\,s} = 5 \times 10^{9} s^{-1}$

Wavelength, $\lambda = \frac{c}{\upsilon} = \frac{3.0\times10^{8}\,ms^{-1}}{5\times10^{9}\,s^{-1}} = 6 \times 10^{-2}$m

Wave number, $\bar{\upsilon} = \frac{1}{\lambda} = \frac{1}{6\times10^{-2}\,m} = 16.66\ m^{-1}$

2.8. $\lambda = 4000$ pm $= 4000 \times 10^{-12}$ m $= 4 \times 10^{-9}$ m

$E = Nh\upsilon = Nh\frac{c}{\lambda}$

$$\therefore N = \frac{E\lambda}{hc} = \frac{1J\times4\times10^{-9}\,m}{(6.626\times10^{-34}\,Js)\times3\times10^{8}\,ms^{-1}}$$

$= 2.012 \times 10^{16}$ photons

2.9. (i) Energy of the photon ,

$$E = h\upsilon = \frac{hc}{\lambda} = \frac{(6.626\times10^{-34}\,Js)\times(3\times10^{8}\,ms^{-1})}{4\times10^{-7}\,m}$$

$$= 4.97 \times 10^{-19}J = \frac{4.97\times10^{-19}}{1.602\times10^{-19}}\ eV = 3.10\ eV$$

(ii) Kinetic energy of emission $\left(\frac{1}{2}mv^2\right)$

$= h\upsilon - h\upsilon_0 = 3.10 - 2.13 = 0.97$ eV

(iii) $\frac{1}{2}mv^2 = 0.97$ eV $= 0.97 \times 1.602 \times 10^{-19}$ J

$\frac{1}{2} \times 9.11 \times 10^{-31}$ kg $\times\ v^2 = 0.97 \times 1.602 \times 10^{-19}$ J

$$v^2 = \frac{0.97\times1.602\times10^{-19}\,J\times2}{9.11\times10^{-31}\,kg}$$

$= 0.341 \times 10^{12} = 34.1 \times 10^{10}$

velocity, $v = \sqrt{34.1\times10^{10}} = 5.84 \times 10^{5}\ ms^{-1}$

2.10. IE, $E = Nh\upsilon = Nh\frac{c}{\lambda}$

$$= \frac{(6.02\times10^{23}\,mol^{-1})\times(6.626\times10^{-34}\,Js)\times(3\times10^{8}\,ms^{-1})}{242\times10^{-9}\,m}$$

$= 4.945 \times 10^{5}$ J mol^{-1} $= 494.5$ kJ mol^{-1}

2.11. Energy emitted by the bulb = 25 watt
$= 25 Js^{-1}$ (1 watt = $1 Js^{-1}$)

Energy of one photon, $E = h\upsilon = h\frac{c}{\lambda}$

Here $\lambda = 0.57\ \mu m = 0.57 \times 10^{-6}$ m ($1\ \mu m = 10^{-6}$ m)

$$\therefore E = \frac{(6.62\times10^{-34}\,Js)\times(3\times10^{8}\,ms^{-1})}{0.57\times10^{-6}\,m} = 3.48 \times 10^{-19}\ J$$

No. of photons emitted per second

$$= \frac{\text{Total energy}}{\text{Energy of one photon}}$$

$$= \frac{25Js^{-1}}{3.48\times10^{-19}\,J} = 7.18 \times 10^{19}$$

2.12. Threshold wavelength (λ_0)
$= 6800$ Å $= 6800 \times 10^{-10}$m

Threshold frequency $(\upsilon_0) = \frac{c}{\lambda_0} = \frac{3\times10^{8}\,ms^{-1}}{6800\times10^{-10}\,m}$

$= 4.41 \times 10^{14}\ s^{-1}$

Work function $(W_0) = h\upsilon_0$
$= (6.626 \times 10^{-34}$ Js$)$ $(4.41 \times 10^{14}\ s^{-1})$
$= 2.92 \times 10^{-19}$ J

2.13. $\bar{\upsilon} = R\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right] = 109677\left[\frac{1}{2^2} - \frac{1}{4^2}\right]$ cm^{-1}

$= 20564$ cm^{-1}

$\lambda = \frac{1}{\bar{\upsilon}} = \frac{1}{20564\,cm^{-1}} = 486 \times 10^{-7}$ cm

$= 486 \times 10^{-9}$ m $= 486$ nm

2.14. $E_n = \frac{-21.8\times10^{-19}}{n^2}$ J atom^{-1}

For ionisation from 5th orbit, $n_1 = 5$, $n_2 = \infty$

$\Delta E = E_2 - E_1 = -21.8 \times 10^{-19}\left[\frac{1}{n_2^2} - \frac{1}{n_1^2}\right]$

$= 21.8 \times 10^{-19}\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$

$= 21.8 \times 10^{-19}\left[\frac{1}{5^2} - \frac{1}{\infty}\right] = 8.72 \times 10^{-20}$ J

For ionisation from 1st orbit, $n_1 = 1$, $n_2 = \infty$

$\Delta E' = 21.8 \times 10^{-19}\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$

$$= 21.8 \times 10^{-19} \left[\frac{1}{1^2} - \frac{1}{\infty}\right] = 21.8 \times 10^{-19}\ J$$

$$\frac{\Delta E'}{\Delta E} = \frac{21.8 \times 10^{-19} J}{8.72 \times 10^{-20} J} = 25$$

Thus the energy required to remove electron from 1st orbit is 25 times than that required to remove an electron from 5th orbit.

2.15. Number of lines produced when electron from the n^{th} shell drops to ground state

$$= \frac{n(n-1)}{2} = \frac{6(6-1)}{2} = \frac{6 \times 5}{2} = 15$$

These are produced due to the following transitions:

$6 \rightarrow 5$	$5 \rightarrow 4$	$4 \rightarrow 3$	$3 \rightarrow 2$	$2 \rightarrow 1$
$6 \rightarrow 4$	$5 \rightarrow 3$	$4 \rightarrow 2$	$3 \rightarrow 1$	
$6 \rightarrow 3$	$5 \rightarrow 2$	$4 \rightarrow 1$		
$6 \rightarrow 2$	$5 \rightarrow 1$			
$6 \rightarrow 1$				
(5 lines)	(4 lines)	(3 lines)	(2 lines)	(1 line)

2.16. (i) $E_n = \frac{-2.17 \times 10^{-18}}{n^2} J$

$$\therefore E_5 = \frac{-2.17 \times 10^{-18}}{5^2} = -8.72 \times 10^{-20} J$$

(ii) For H - atom, $r_n = 0.529 \times n^2 A^0$

$r_5 = 0.529 \times 5^2 = 13.225 A^0 = 1.3225$ nm

2.17. For Balmer series, $n_1 = 2$,

Hence $\bar{\upsilon} = R\left[\frac{1}{2^2} - \frac{1}{n_2^2}\right]$

$\bar{\upsilon} = \frac{1}{\lambda}$. For λ to be the longest (maximum) $\bar{\upsilon}$ should be minimum. This can be so when n_2 is minimum. ie, $n_2 = 3$.

Hence $\bar{\upsilon} = (1.097 \times 10^7 m^{-1})\left[\frac{1}{2^2} - \frac{1}{3^2}\right]$

$$= 1.097 \times 10^7 \times \frac{5}{36} m^{-1} = 1.523 \times 10^6 m^{-1}$$

2.18. As the ground state electronic energy is -2.18×10^{-11} ergs

$$E_n = \frac{-2.18 \times 10^{-11}}{n^2}$$

$$\therefore \Delta E = E_5 - E_1 = -2.18 \times 10^{-11}\left(\frac{1}{1^2} - \frac{1}{5^2}\right)$$

$$= 2.18 \times 10^{-11} \times \frac{24}{25} = 2.09 \times 10^{-11} \text{ ergs} = 2.09 \times 10^{-18} J$$

$(1 \text{ erg} = 10^{-7} J)$

$$\lambda = \frac{ch}{\Delta E} = \frac{3 \times 10^{10} cm \times 6.626 \times 10^{-27} ergs}{2.09 \times 10^{-11} ergs} = 951.1 Å$$

2.19. $\Delta E = E_\infty - E_2 = 0 - \left(\frac{-2.18 \times 10^{-18} J\,atom^{-1}}{2^2}\right)$

$= 5.45 \times 10^{-19} J\ atom^{-1}$

$$\Delta E = \frac{hc}{\lambda} \quad \because \lambda = \frac{hc}{\Delta E}$$

$$= \frac{(6.626 \times 10^{-34} Js) \times (3 \times 10^8 ms^{-1})}{5.45 \times 10^{-19} J}$$

$= 3.647 \times 10^{-7} m = 3.647 \times 10^{-5}$ cm

2.20. $\lambda = \frac{h}{mv} = \frac{6.626 \times 10^{34} Js}{(9.11 \times 10^{-31} kg)(2.05 \times 10^7 ms^{-1})}$

$= 3.55 \times 10^{-11}$ m $\quad (1J = 1kg\ m^2s^{-2})$

2.21. $m = 9.1 \times 10^{-31}$ kg $\quad$ K.E $= 3.0 \times 10^{-25}$ J

$$K.E. = \frac{1}{2} mv^2$$

$$v = \sqrt{\frac{2 \times K.E.}{m}} = \sqrt{\frac{2 \times 3.0 \times 10^{-25} J}{9.1 \times 10^{-31}}} = 812\ ms^{-1}$$

$$\lambda = \frac{h}{mv} = \frac{6.626 \times 10^{-34} Js}{(9.1 \times 10^{-31} kg)(8.12 ms^{-1})}$$

$= 8.967 \times 10^{-7} m = 8967 Å$

2.22. Number of electrons $Na^+ = 10$; $K^+ = 18$, $Mg^{2+} = 10$ $Ca^{2+} = 18$, $S^{2-} = 18$, Ar = 18

Hence, isoelectronic species are

i) Na^+, Mg^{2+}; ii) K^+, Ca^{2+}, S^{2-}, Ar

2.23. (i) a) ${}^1_1H = 1s^1$ $\quad \therefore H^+ = 1s^0$

b) ${}^{23}_{11}Na = 1s^2, 2s^2, 2p^6, 3s^1$; $Na^+ = 1s^2, 2s^2, 2p^6$

c) ${}^{16}_8O = 1s^2, 2s^2, 2p^4$; $O^{2-} = 1s^2, 2s^2, 2p^6$

d) ${}_9F = 1s^2, 2s^2, 2p^5$; $F^- = 1s^2, 2s^2, 2p^6$

(ii) (a) $1s^2, 2s^2, 2p^6, 3s^1$ (Z = 11)

(b) $1s^2, 2s^2, 2p^3$ (Z = 7)

(c) $1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^2, 3d^6$ (Z = 26)

2.24. For g subshell, $l = 4$

As $l = 0$ to $(n-1)$, to have $l = 4$,

minimum value of $n = 5$

2.25. For 3d orbital, $n = 3, l = 2$

For $l = 2$, $m_l = -2, -1, 0, +1, +2$

2.26. (i) In an atom no. of protons = no. of electrons = 29

(ii) Atomic no. = no. of protons or electrons = 29

Electronic configuration

$= 1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^1, 3d^{10}$

2.27. No. of electrons in $H_2 = 2$ $\therefore$ $H_2^+ = 1$ electron

No. of electrons in $O_2 = 16$ $\therefore$ $O_2^+ = 15$ electrons

2.28. (i) When $n = 3$, $l = 0, 1, 2$

When $l = 0$; $m_l = 0$

When $l = 1$, $m_l = -1, 0, +1$

When $l = 2$, $m_l = -2, -1, 0, +1, +2$

(ii) For 3d -orbital, $n = 3, l = 2$

$\therefore m_l = -2, -1, 0, +1, +2$

(iii) 1p is not possible because when $n = 1$, $l = 0$ only (for p, $l = 1$)

2s is possible because when $n = 2$, $l = 0, 1$ (for s, $l = 0$)

2p is possible because when $n = 2$, $l = 0, 1$ (for p, $l = 1$)

3f is not possible because when $n = 3$, $l = 0, 1, 2$. (for f, $l = 3$)

2.29. (a) 1s (b) 3p (c) 4d (d) 4f

2.30. (a) Not possible because $n \neq 0$

(b) Possible

(c) Not possible because when $n = 1$, $l \neq 1$

(d) Possible

(e) Not possible because when $n = 3$, $l \neq 3$

(f) Possible

2.31. (i) Total electrons in $n = 4$ are $2n^2$ ie, $2 \times 4^2 = 32$.

Half of them ie, 16 electrons have $m_s = -\frac{1}{2}$

(ii) $n = 3$, $l = 0$ means 3s orbital which can have 2 electrons.

2.32. According to Bohr postulate,

angular momentum, $mvr = n.\dfrac{h}{2\pi}$

$$2\pi r = n.\frac{h}{mv} \text{ ---------- (i)}$$

According to de-Broglie relation, $\lambda = \dfrac{h}{mv}$

Substituting the value in eqn. (i)

$$2\pi r = n\lambda$$

Thus circumference ($2\pi r$) of the Bohr orbital for hydrogen atom is an integral multiple of de-Broglie wavelength.

2.33. For H like atom $\bar{\upsilon} = \dfrac{2\pi^2 me^4 z^2}{ch^3}\left(\dfrac{1}{n_1^2} - \dfrac{1}{n_2^2}\right)$

$$= RZ^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

$\therefore$ For He^+ spectrum, Balmer transition $n = 4$ to $n = 2$

$$\bar{\upsilon} = \frac{1}{\lambda} = RZ^2\left(\frac{1}{2^2} - \frac{1}{4^2}\right) = R \times 2^2\left(\frac{1}{4} - \frac{1}{16}\right)$$

$$= 4R \times \frac{3}{16} = \frac{3R}{4}$$

For H spectrum $\bar{\upsilon} = \dfrac{1}{\lambda} = R\left(\dfrac{1}{n_1^2} - \dfrac{1}{n_2^2}\right) = \dfrac{3}{4}R$

$$\frac{1}{n_1^2} - \frac{1}{n_2^2} = \frac{3}{4}$$

Which can be so for $n_1 = 1$ and $n_2 = 2$ ie, the transition is from $n = 2$ to $n = 1$.

2.34. For H-like atoms, $E_n = \dfrac{-2\pi^2 me^4 Z^2}{m^2 h^2}$

For H- like atoms, $IE = E_\infty - E_1$

$$= 0 - \left(\frac{-2\pi^2 me^4}{1^2 h^2}\right) = \frac{2\pi^2 me^4}{h^2}$$

$= 2.18 \times 10^{-18}$ J atom^{-1} (given)

$\therefore$ Energy required for the given process $= E_\infty - E_1$

$$= -\left(\frac{-2\pi^2 me^4 \times 2^2}{1^2 \times h^2}\right) = 4 \times \frac{2\pi^2 me^4}{h^2}$$

$= 4 \times 2.18 \times 10^{-18}$ J $= 8.72 \times 10^{-18}$ J

2.35. Diameter $= 0.15$nm $= 0.15 \times 10^{-9}$ m $= 1.5 \times 10^{-10}$ m.

Length along which atoms to be placed

$= 20$ cm $= 20 \times 10^{-2}$ m $= 2 \times 10^{-1}$ m

No. of C atoms which can be placed

$$= \frac{2 \times 10^{-1}\,m}{1.5 \times 10^{-10}\,m} = 1.33 \times 10^9$$

2.36. Total length = 3.0 cm

Total no. of atoms along the length $= 2 \times 10^8$

Diameter of each atom $= \frac{3.0 \text{ cm}}{2\times10^8} = 1.5\times10^{-8}$ cm

$\therefore$ Radius of the C atom $= \frac{1.5\times10^{-8} \text{ cm}}{2}$

$= 0.75 \times 10^{-8}$ cm

$= 0.75 \times 10^{-10}$ m $= 0.075 \times 10^{-9}$ m $= 0.075$ nm

2.37. (a) Radius $= \frac{2.6\text{Å}}{2} = 1.3\text{Å} = 1.3 \times 10^{-10}$ m

$= 130 \times 10^{-12}$ m $= 130$ pm

(b) Given length $= 1.6$ cm $= 1.6 \times 10^{-2}$ m

Diameter of one atom $= 2.6\text{Å} = 2.6 \times 10^{-10}$ m

$\therefore$ No. of atoms present along the length

$= \frac{1.6\times10^{-2} \text{ m}}{2.6\times10^{-10} \text{m}} = 6.154 \times 10^7$

2.38. Charge carried by one electron $= 1.6022 \times 10^{-19}$ C

$\therefore$ Electrons present in particle carrying 2.5×10^{-16}C

Charge $= \frac{2.5\times10^{-16}}{2.6\times10^{-10}\text{m}} = 1560$

2.39. No. of electrons $= \frac{\text{Total charge}}{\text{Charge of one electron}}$

$= \frac{-1.282\times10^{-18}\text{C}}{1.6022\times10^{-19}\text{C}}$

2.40. Heavy atoms have a heavy nucleus carrying a large amount of positive charge. Hence, some α-particles are easily deflected back on hitting the nucleus. Also a number of α-particles are deflected through small angles because of large positive charge on the nucleus. If light atoms are used, their nuclei will be light and moreover, they will have small positive charge on the nucleus. Hence, the number of particles deflected back and those deflected through some angle will be negligible.

2.41. Atomic number of an element is fixed. However, mass number is not fixed as it depends upon the isotope taken. Hence, it is essential to indicate mass number.

2.42. Mass no. = 81 ie, p + n = 81

If number of protons is x, then neutrons

$= \frac{31.7}{100} = 1.317$ x

$\therefore$ x + 1.317 x = 81

$2.317x = 81;\ x = \frac{81}{2.317} = 35$

Thus protons = 35, neutrons = 81 – 35 = 46

Hence, symbol is ${}^{81}_{36}\text{Br}$.

2.43. Suppose no. of electrons in the ion = x

no. of neutrons $= x + \frac{11.1}{100}x = 1.111x$

No. of electrons in the neutral atom = x – 1

No. of protons in the neutral atom = x – 1

Mass no. = no. of neutrons + no. of protons

ie, 37 = 1.111x + x – 1

2.111x = 37 + 1 = 38

$x = \frac{38}{2.111} = 18$

No. of protons = Atomic no. = x – 1 = 18 – 1 = 17

Hence, the symbol of the ion is ${}^{37}_{17}Cl$.

2.44. Suppose number of electrons in the ion M^{3+} = x

No. of neutrons $= x + \frac{30.4}{100}x = 1.304x$

No. of electrons in the neutral atom = x + 3

No. of protons = x + 3

Mass no. = No. of protons + No. of neutrons

56 = x + 3 + 1.304x

$2.304x = 53 \quad \therefore \frac{53}{2.304} = 23$

No. of protons = Atomic no. = x + 3 = 23 + 3 = 26

Hence, the symbol of the ion is ${}^{56}_{26}Fe^{3+}$.

2.45. Cosmic rays < X-rays < amber light < microwave <FM

2.46. $E = Nh\upsilon = \frac{Nhc}{\lambda}$

$= \frac{(5.6\times10^{24})(6.626\times10^{-34}\text{Js})(3.0\times10^8\text{ms}^{-1})}{337.1\times10^{-9}\text{m}}$

$= 3.3 \times 10^6$ J

2.47. $\lambda = 616$ nm $= 616 \times 10^{-9}$m

(a) Frequency, $\upsilon = \frac{c}{\lambda} = \frac{3.0\times10^8\text{ms}^{-1}}{616\times10^{-9}} = 4.87 \times 10^{14}\ \text{s}^{-1}$

(b) Velocity of radiation $= 3.0 \times 10^8\ \text{ms}^{-1}$

$\therefore$ Distance travelled in 30s $= 30 \times 3 \times 10^8$ m

$= 9.0 \times 10^9$ m

(c) $E = h\upsilon = \frac{hc}{\lambda} = \frac{(6.626\times10^{-34}Js)(3.0\times10^{8}ms^{-1})}{616\times10^{-9}m}$

$= 32.27 \times 10^{-20}$ J

(d) No. of quanta in 2J energy = $\frac{2}{32.27\times10^{-20}}$

$= 6.2 \times 10^{18}$

2.48. Energy of one photon = $\frac{hc}{\lambda}$

$= \frac{(6.626\times10^{-34}Js)(3\times10^{8}ms^{-1})}{(600\times10^{-9}m)} = 3.313 \times 10^{-19}$ J

Total energy received = 3.15×10^{-18}J

No. of photons received = $\frac{3.15\times10^{-18}J}{3.313\times10^{-19}J} = 9.51 = 10$

2.49. Frequency = $\frac{1}{2\times10^{-9}s} = 0.5 \times 10^{9} s^{-1}$ (1ns = 10^{-9}s)

Energy = Nhυ

$= (2.5 \times 10^{15}) \times (6.626 \times 10^{-34}Js)\ (0.5 \times 10^{9}\ s)$

$= 8.28 \times 10^{-10}$ J

2.50. $\lambda_1 = 589nm = 589 \times 10^{-9}$ m

$\upsilon_1 = \frac{c}{\lambda_1} = \frac{3.0\times10^{8}ms^{-1}}{589\times10^{-9}m} = 5.093\times10^{14}s^{-1}$

$\lambda_2 = 589.6nm = 589.6 \times 10^{-9}$ m

$\upsilon_2 = \frac{c}{\lambda_2} = \frac{3.0\times10^{8}ms^{-1}}{589.6\times10^{-9}m} = 5.088\times10^{14}s^{-1}$

$\Delta E = E_2 - E_1 = h(\upsilon_2 - \upsilon_1)$

$= (6.626 \times 10^{-34}\ Js)\ [5.093 \times 10^{14} - 5.088 \times 10^{14}]$

$= 3.31 \times 10^{-22}$ J

2.51. (a) $\lambda_0 = \frac{c}{\upsilon_0} = \frac{3.0\times10^{8}ms^{-1}}{4.59\times10^{14}s^{-1}} = 6.54 \times 10^{-7}$ m

$= 6.54 \times 10^{-9}$ m = 654 nm

(b) Work function, $W_0 = h\upsilon_0 = h_c/\lambda_0$

$\upsilon_0 = \frac{W_0}{h} = \frac{1.9\times1.602\times10^{-19}J}{6.626\times10^{-34}Js} = 4.59 \times 10^{14} s^{-1}$

(c) Kinetic energy of ejected electron

$= h(\upsilon - \upsilon_0) = hc\left(\frac{1}{\lambda} - \frac{1}{\lambda_0}\right)$

$= (6.626 \times 10^{-34}\ Js) \times (3.0 \times 10^{8}\ ms^{-1})$

$\left[\frac{1}{500\times10^{-9}m} - \frac{1}{654\times10^{-9}m}\right]$

$= \frac{6.626\times3.0\times10^{-26}}{10^{-9}}\left(\frac{154}{500\times654}\right)J = 9.36 \times 10^{-20}$ J

K.E. $= \frac{1}{2}mv^2 = 9.36 \times 10^{-20}$ J

$\frac{1}{2} \times 9.11 \times 10^{-31}\ kg \times v^2$

$= 9.36 \times 10^{-20}\ kg\ m^2s^{-2}$

$v^2 = \frac{9.36\times10^{-20}kgm^2s^{-2}\times2}{9.11\times10^{-31}kg} = 20.55\times10^{10}\ m^2s^{-2}$

$v = 4.54 \times 10^{5}\ ms^{-1}$

2.52. (a) Suppose threshold wavelength, λ_0

Then $h(\upsilon - \upsilon_0) = \frac{1}{2}mv^2$

$hc\left(\frac{1}{\lambda} - \frac{1}{\lambda_0}\right) = \frac{1}{2}mv^2$

$\frac{hc}{10^{-9}}\left(\frac{1}{450} - \frac{1}{\lambda_0}\right) = \frac{1}{2}m\ (4.35 \times 10^{6})^2$----- (1)

$\frac{hc}{10^{-9}}\left(\frac{1}{500} - \frac{1}{\lambda_0}\right) = \frac{1}{2}m\ (2.55 \times 10^{6})^2$----- (2)

$\frac{hc}{10^{-9}}\left(\frac{1}{400} - \frac{1}{\lambda_0}\right) = \frac{1}{2}m\ (5.20 \times 10^{6})^2$----- (3)

Eqn. $(1)/(2) \Rightarrow \frac{\lambda_0 - 450}{450\lambda_0} \times \frac{500\lambda_0}{\lambda_0 - 500} = \left(\frac{4.35}{2.55}\right)^2$

$\frac{\lambda_0 - 450}{\lambda_0 - 500} = \frac{450}{500}\left(\frac{4.35}{2.55}\right)^2 = 2.619$

$\lambda_0 - 450 = 2.619\lambda_0 - 1309.5$

$1.619\lambda_0 = 859.5$

$\therefore \lambda_0 = \frac{859.5}{1.619} = 531nm$

(b) Substituting the value of λ_0 in eqn. (3)

$\frac{h\times3\times10^{8}}{10^{-9}}\left(\frac{1}{400} - \frac{1}{531}\right)$

$= \frac{1}{2} \times (9.11 \times 10^{-31}) \times (5.20 \times 10^{6})^2$

$h = 6.66 \times 10^{-34}$ Js

2.53. Energy of the incident radiation

= Work function + K. E. of photon = $h\upsilon$

$$= \frac{hc}{\lambda} = \frac{(6.626 \times 10^{34} Js)(3.0 \times 10^8 ms^{-1})}{(256.7 \times 10^{-9} m)}$$

$= 7.74 \times 10^{-19}$ J

$= 4.83$ eV $(1eV = 1.602 \times 10^{-19} J)$

The potential applied gives the kinetic energy to the electron.

Hence, K.E. of the electron = 0.35eV

∴ Work function = 4.83eV – 0.35 eV = 4.48 eV

2.54. Energy of the incident photon $= \frac{hc}{\lambda}$

$$= \frac{(6.626 \times 10^{-34} Js)(3.0 \times 10^8 ms^{-1})}{(150 \times 10^{-12} m)}$$

$= 13.25 \times 10^{-16}$ J

Energy of the ejected electron $\frac{1}{2} mv^2$

$= \frac{1}{2} \times 9.11 \times 10^{-31}$ kg $\times (1.5 \times 10^7 ms^{-1})^2$

$= 1.025 \times 10^{-16}$ J

Energy with which electron was bound to the nucleus

= Energy of incident photon – energy of electron

$= 13.25 \times 10^{-16} J - 1.025 \times 10^{-16} J = 12.225 \times 10^{-16} J$

$$= \frac{12.225 \times 10^{-16}}{1.602 \times 10^{-19}} eV = 7.63 \times 10^3 eV$$

2.55. $\upsilon = \frac{c}{\lambda} = \frac{3 \times 10^8 ms^{-1}}{1285 \times 10^{-9} m}$

$$= 3.29 \times 10^{15} \left[\frac{1}{3^2} - \frac{1}{n^2}\right]$$

$$\frac{1}{n^2} = \frac{1}{9} - \frac{3 \times 10^8}{1285 \times 10^{-9}} \times \frac{1}{3.29 \times 10^{15}}$$

$= 0.111 - 0.071 = 0.04 = \frac{1}{25}$

$n^2 = 25$ or $n = \sqrt{25} = 5$

The radiation corresponding to 1285 nm lies in the infrared region.

2.56. Radius of nth orbit of H-like atoms

$$= \frac{0.529n^2}{Z} \mathring{A} = \frac{52.9n^2}{Z} pm$$

$$r_1 = 1.3225 \text{ nm} = 1322.5 \text{ pm} = \frac{52.9n_1^2}{Z}$$

$r_2 = 211.6pm = 52.9n_2^2/Z$

$$\frac{r_1}{r_2} = \frac{1322.5}{211.6} = \frac{52.9n_1^2}{Z} \times \frac{Z}{52.9n_2^2} = \frac{n_1^2}{n_2^2}$$

$$\frac{n_1^2}{n_2^2} = 6.25, \quad \frac{n_1}{n_2} = \sqrt{6.25} = 2.5$$

If $n_2 = 2$, $n_1 = 5$. Thus the transition is from 5th orbit to 2nd orbit. It belongs to Balmer series.

$$\bar{\upsilon} = 1.097 \times 10^7 m^{-1} \left(\frac{1}{2^2} - \frac{1}{5^2}\right)$$

$$= 1.097 \times 10^7 \times \frac{21}{100} m^{-1}$$

$$\lambda = \frac{1}{\bar{\upsilon}} = \frac{100}{1.097 \times 10^7} m = 434 \times 10^{-9} m = 434nm$$

It lies in the visible region.

2.57. $v = 1.6 \times 10^6 ms^{-1}$, $\lambda = ?$ $m = 9.11 \times 10^{-31}$ kg

$$\lambda = \frac{h}{mv} = \frac{6.626 \times 10^{-34} kgm^2s^{-1}}{(9.11 \times 10^{-31} kg)(1.6 \times 10^6 ms^{-1})}$$

$= 4.55 \times 10^{-10} m = 455$ pm

2.58. Mass of neutron = 1.675×10^{-27} kg

$\lambda = 800 \text{ pm} = 800 \times 10^{-12}$ m

$h = 6.626 \times 10^{-34} kgm^2s^{-1}$, $\lambda = \frac{h}{mv}$

$$v = \frac{h}{m\lambda} = \frac{6.626 \times 10^{-34} kgm^2s^{-1}}{(1.675 \times 10^{-27} kg)(800 \times 10^{-12} m)}$$

$= 4.94 \times 10^4 ms^{-1}$

2.59. $\lambda = \frac{h}{mv} = \frac{6.626 \times 10^{-34} kgm^2s^{-1}}{(9.11 \times 10^{-31} kg)(2.19 \times 10^6 ms^{-1})}$

$= 3.32 \times 10^{-10} m = 332pm.$

2.60. $v = 4.37 \times 10^5 ms^{-1}$, $m = 0.1$ kg

$h = 6.626 \times 10^{-34} kgm^2s^{-1}$

$$\lambda = \frac{h}{mv} = \frac{6.626 \times 10^{-34} kgm^2s^{-1}}{0.1kg \times 4.37 \times 10^3 ms^{-1}} = 1.516 \times 10^{-28}\ m$$

2.61. $\Delta x = 0.002\ nm = 2 \times 10^{-3}\ nm = 2 \times 10^{-12}\ m$

$$\Delta x . \Delta p = \frac{h}{4\pi}$$

$$\therefore \Delta p = \frac{h}{4\pi\ \Delta x} = \frac{6.626 \times 10^{-34} kgm^2s^{-1}}{4 \times 3.14 \times (2 \times 10^{-12} m)}$$

$$= 2.638 \times 10^{-23}\ kg\ ms^{-1}$$

$$\text{Actual momentum} = \frac{h}{4\pi \times 5 \times 10^{-11} m}$$

$$= \frac{6.626 \times 10^{-34} kgm^2s^{-1}}{4 \times 3.14 \times 5 \times 10^{-11} m} = 1.055 \times 10^{-24}\ kgms^{-1}$$

It cannot be defined as the actual magnitude of momentum as it is smaller than the uncertainty.

2.62. The (n + 1) values of the six electrons are

Electrons:	1	2	3	4	5	6
(n + 1)	4+2	3 + 2	4+ 1	3+2	3+1	4+1
	6	5	5	5	4	5

The arrangement in the increasing order of energy is $5 < 4 = 2 < 3 = 6 < 1$

Thus, the electrons number 2 and 4 and 4 and 6 are the pairs having the same energy.

2.63. 4p electrons being farthest from the nucleus experience the lowest effective nuclear charge.

2.64. (i) 2s is closer to the nucleus than 3s. Hence, 2s will experience larger effective nuclear charge.
(ii) 4d (iii) 3p

2.65. Silicon has greater nuclear charge (+ 14) than aluminium (+ 13). Hence, the unpaired 3p electron in the case of silicon will experience more effective nuclear charge.

2.66. a) $_{15}P = 1s^2, 2s^2, 2p^6, 3s^2, 3px^1, 3py^1, 3pz^1$
No. of unpaired electron, n = 3

(b) $_{14}Si = 1s^2, 2s^2, 2p^6, 3s^2, 3px^1, 3py^1, 3pz^0$;
n = 2

(c) $_{24}Cr = 1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 3d^5, 4s^1$; n = 6

(d) $_{26}Fe = 1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 3d^6, 4s^2$;
n = 4

(e) $_{36}Kr = 1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 3d^{10}, 4s^2$;
n = 0

2.67. a) n = 4, l = 0, 1, 2, 3 (4 subshells → s, p, d, f)

(b) No. of orbitals in the 4th shell = $n^2 = 4^2 = 16$
Each orbital has one electron with $m_s = -½$. Hence there will be 16 electrons with $m_s = -½$